Semantics 2 and Discourse

11-711 Advanced NLP

November 2022

(With thanks to Noah Smith)

Quantifiers in FOL

- Two ways to use variables:
  - refer to one anonymous object from the domain (**existential**; ∃; “there exists”)
  - refer to all objects in the domain (**universal**; ∀; “for all”)

- *A restaurant near CMU serves Indian food*
  $\exists x$ Restaurant(x) ∧ Near(x, CMU) ∧ Serves(x, Indian)
- *All expensive restaurants are far from campus*
  $\forall x$ Restaurant(x) ∧ Expensive(x) ⇒ ¬Near(x, CMU)

Connecting Syntax and Semantics

Semantic Parsing

- Goal: transform a NL statement into MRL (for now, FOL).
- Sometimes called “semantic analysis.”
- As described earlier, this is the literal, context-independent, inference-free meaning of the statement

“Literal, context-independent, inference-free” semantics

- Example: *The ball is red*
- Assigning a specific, grounded meaning involves deciding *which* ball is meant
- Would have to resolve *indexical terms* including pronouns, normal NPs, etc.
- Logical form allows compact representation of such indexical terms (vs. listing all members of the set)
- To retrieve a specific meaning, we combine LF with a particular context or situation (set of objects and relations)
- So LF is a function that maps an initial discourse situation into a new discourse situation (from *situation semantics*)

Compositionality

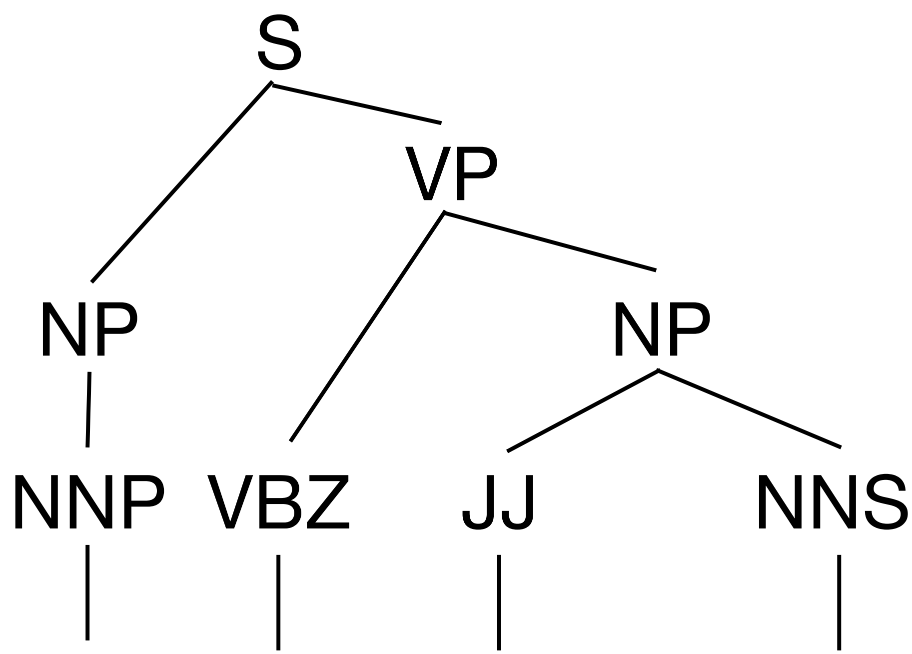
- The meaning of an NL phrase is determined by combining the meaning of its sub-parts.
- There are obvious exceptions ("*hot dog*," "*straw man*," "*New York*," etc.).
- Note: J&M II book uses an event-based FOL representation, but I'm using a simpler one without events.

- **Big idea:** start with parse tree, build semantics on top using FOL with λ-expressions.

Extension: Lambda Notation

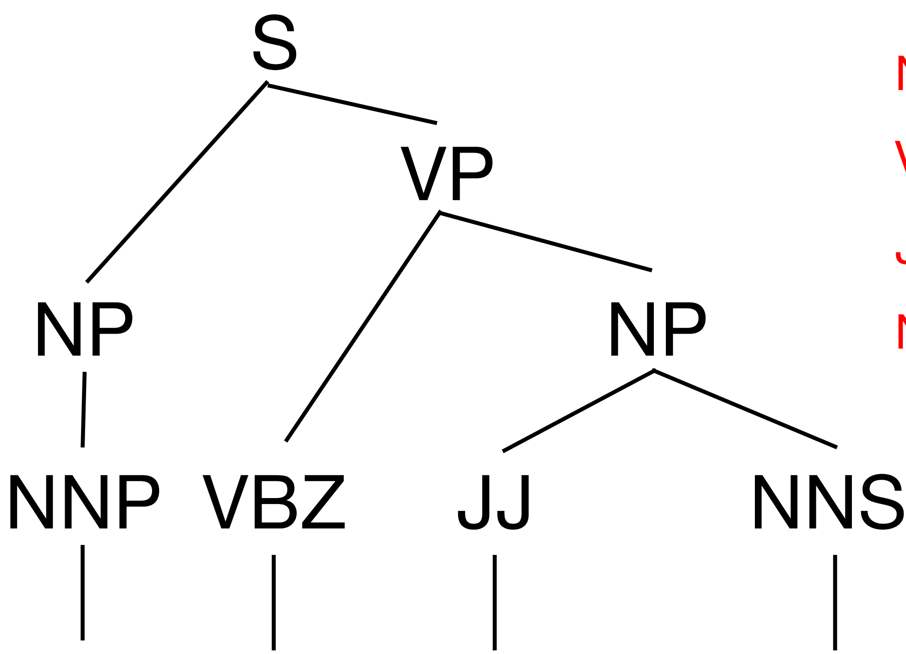
- A way of making anonymous functions.
- λx. (*some expression mentioning x*)
  - Example: λx.Near(x, CMU)
  - Trickier example: λx.λy.Serves(y, x)
- Lambda reduction: substitute for the variable.
  - (λx.Near(x, CMU))(LulusNoodles)
    becomes
    Near(LulusNoodles, CMU)

An Example



- *Noah likes expensive restaurants*.
- ∀x Restaurant(x) ∧ Expensive(x) ⇒ Likes(Noah, x)

An Example



NNP $\rightarrow$ Noah $\{$ Noah $\}$

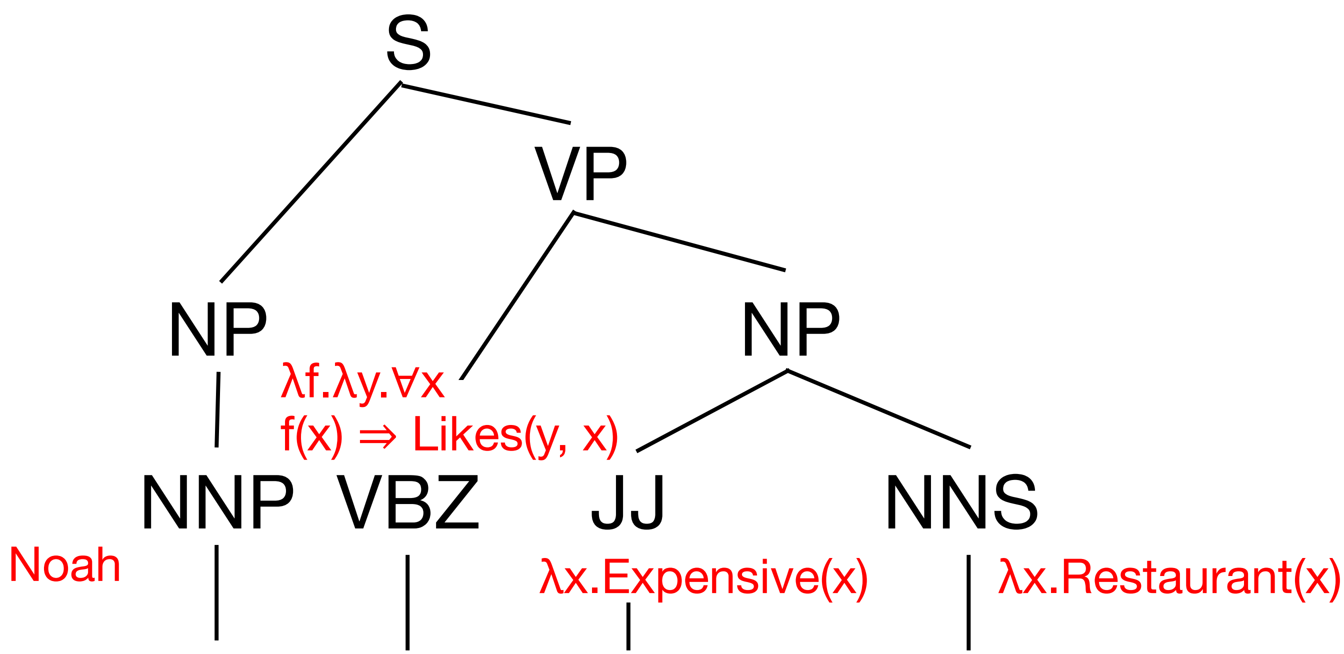
VBZ $\rightarrow$ likes $\{ \lambda f.\lambda y.\forall x\ f(x) \Rightarrow \text{Likes}(y, x) \}$

JJ $\rightarrow$ expensive $\{ \lambda x.\text{Expensive}(x) \}$

NNS $\rightarrow$ restaurants $\{ \lambda x.\text{Restaurant}(x) \}$

- *Noah likes expensive restaurants*.
- $\forall x\ \text{Restaurant}(x) \wedge \text{Expensive}(x) \Rightarrow \text{Likes}(\text{Noah}, x)$

An Example



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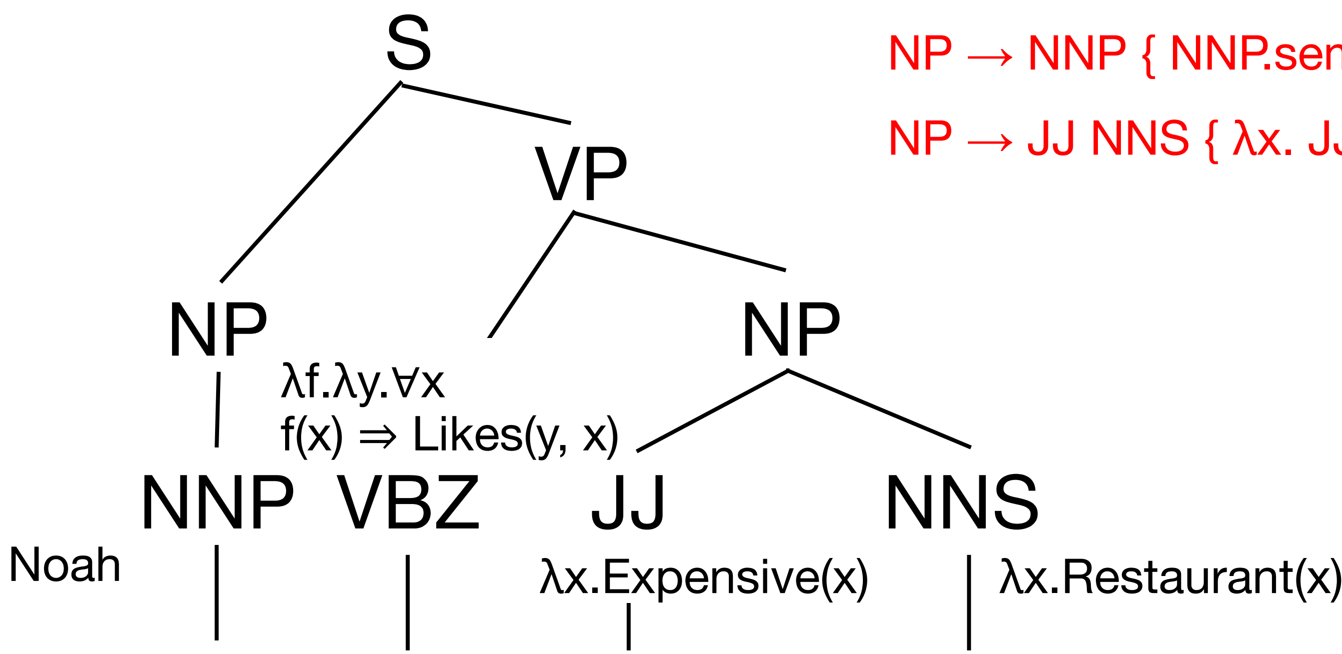
An Example

NP → NNP { NNP.sem }

NP → JJ NNS { λx. JJ.sem(x) ∧ NNS.sem(x) }



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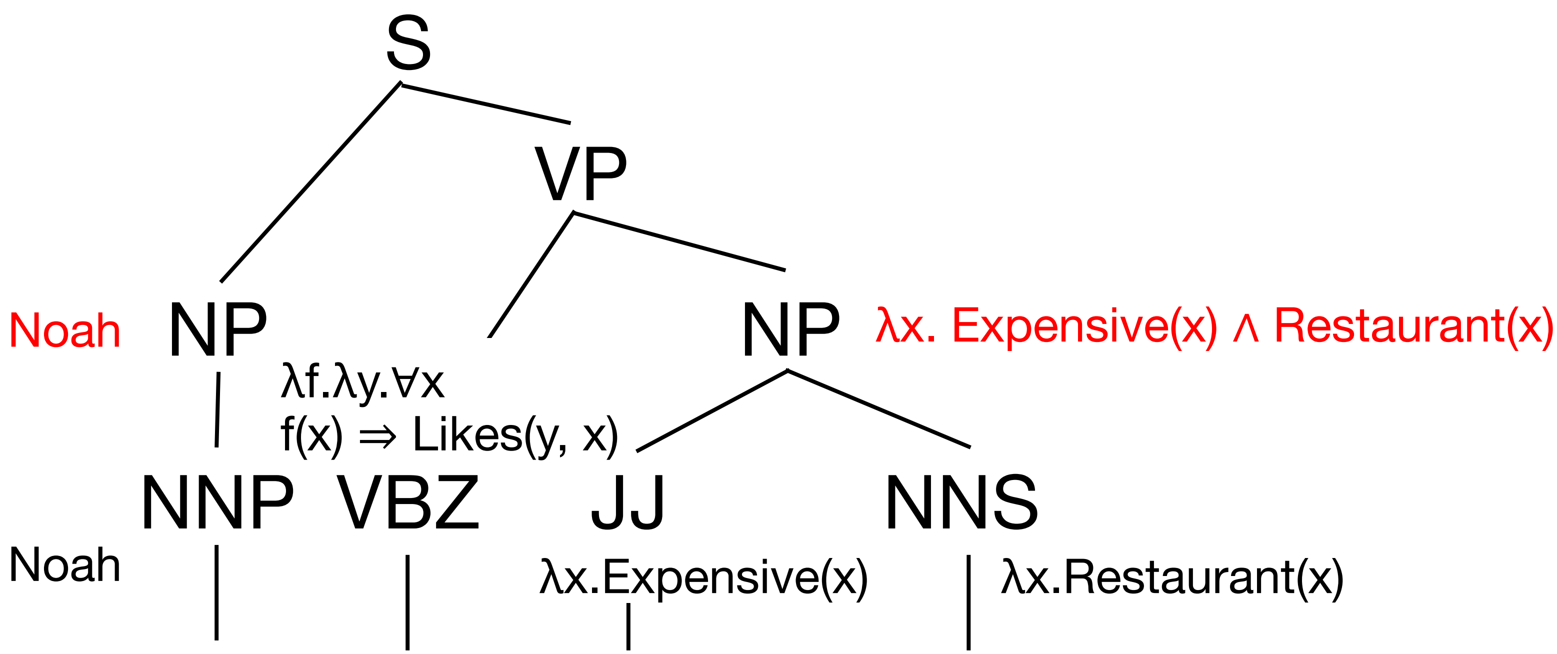

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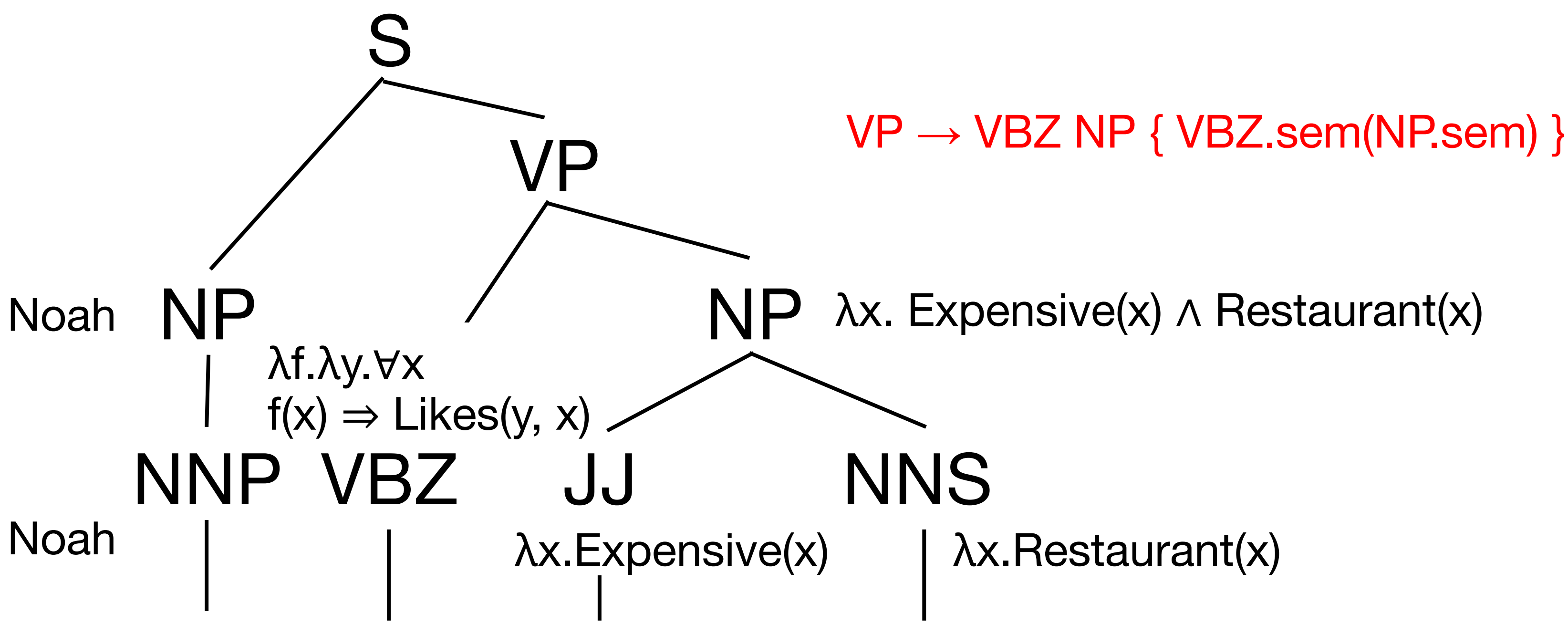

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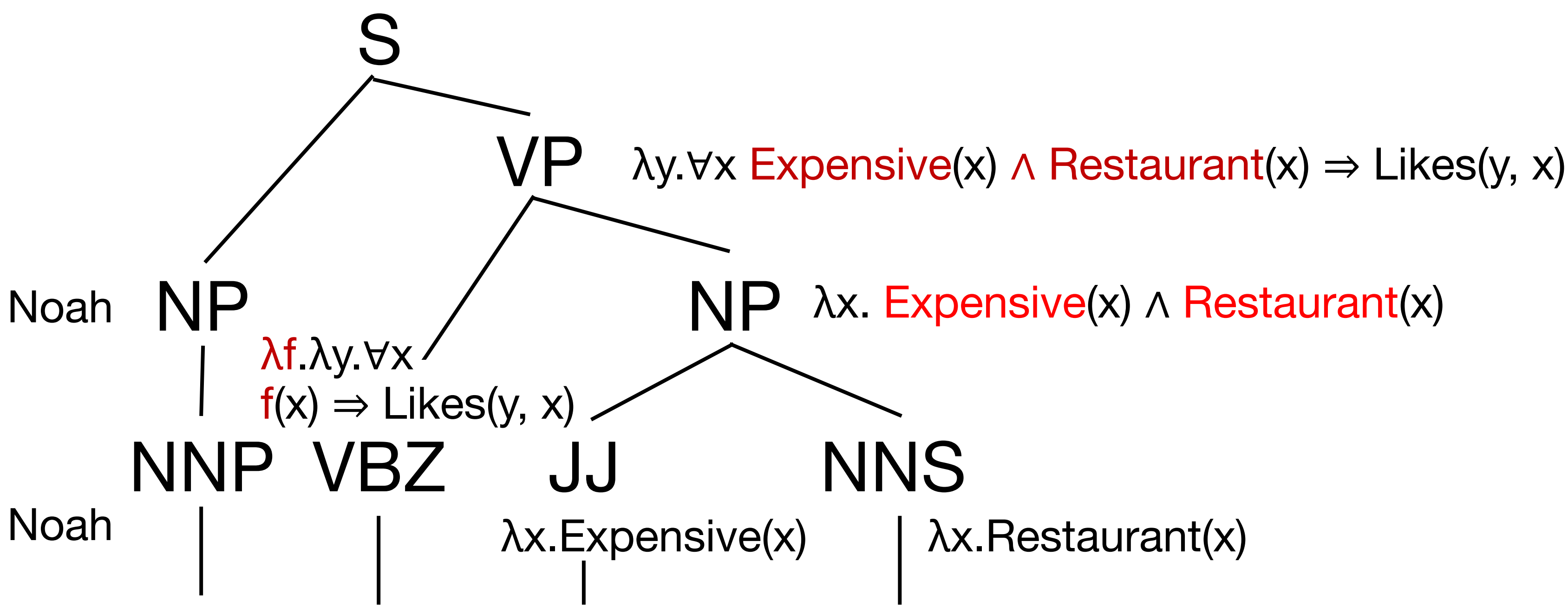
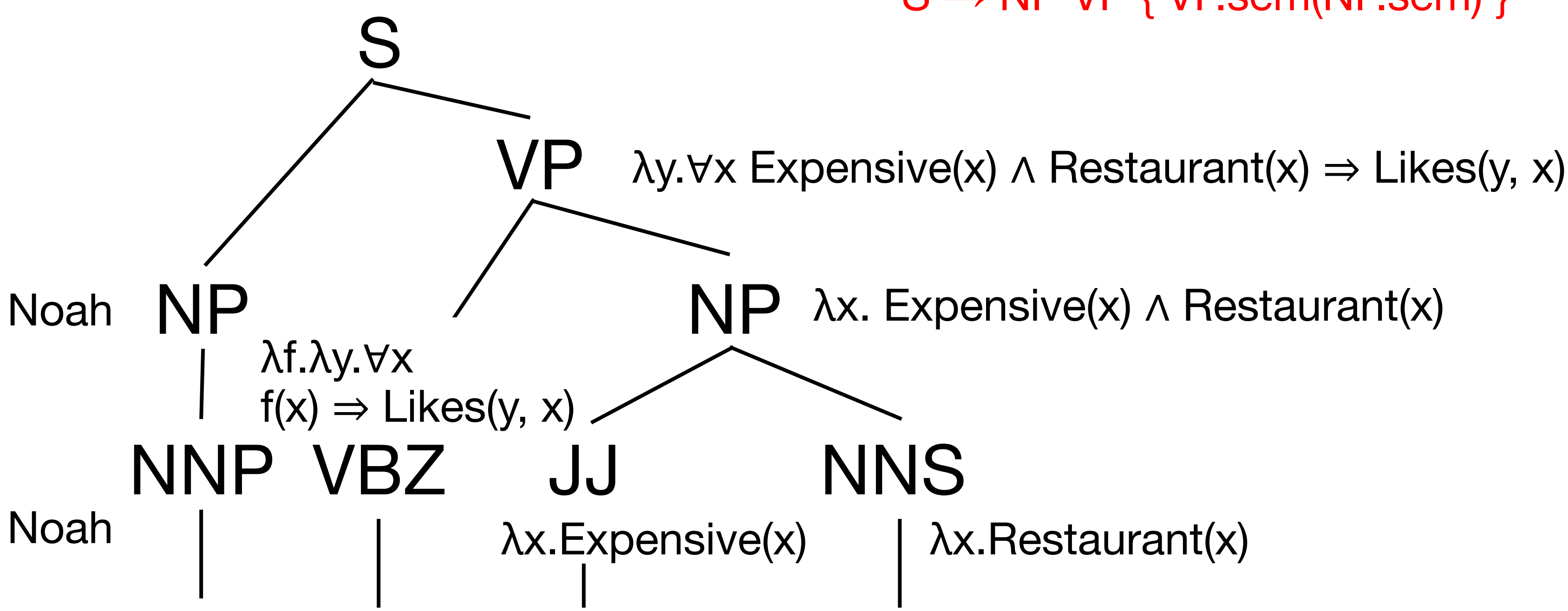


- *Noah likes expensive restaurants*.
- ∀x Restaurant(x) ∧ Expensive(x) ⇒ Likes(Noah, x)

An Example

S → NP VP { VP.sem(NP.sem) }



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- ∀x Restaurant(x) ∧ Expensive(x) ⇒ Likes(Noah, x)

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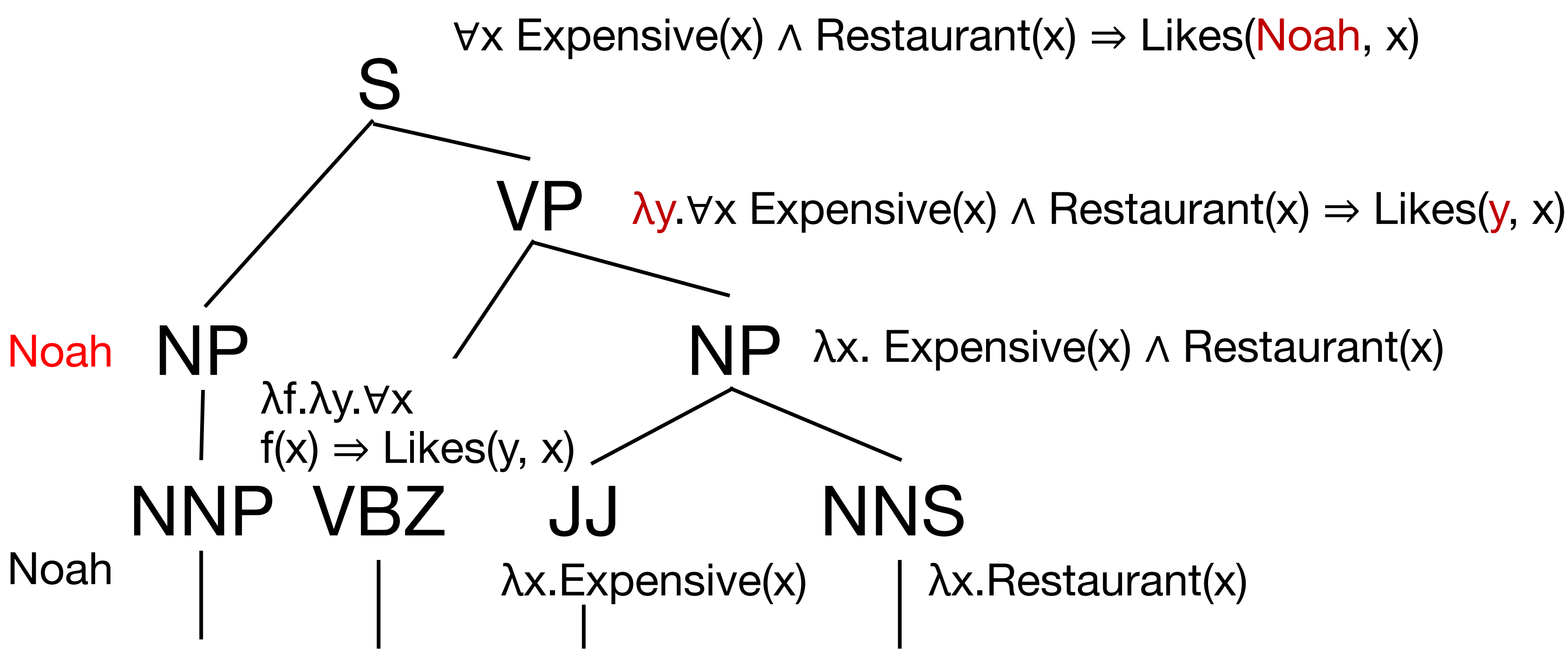

- *Noah likes expensive restaurants*.
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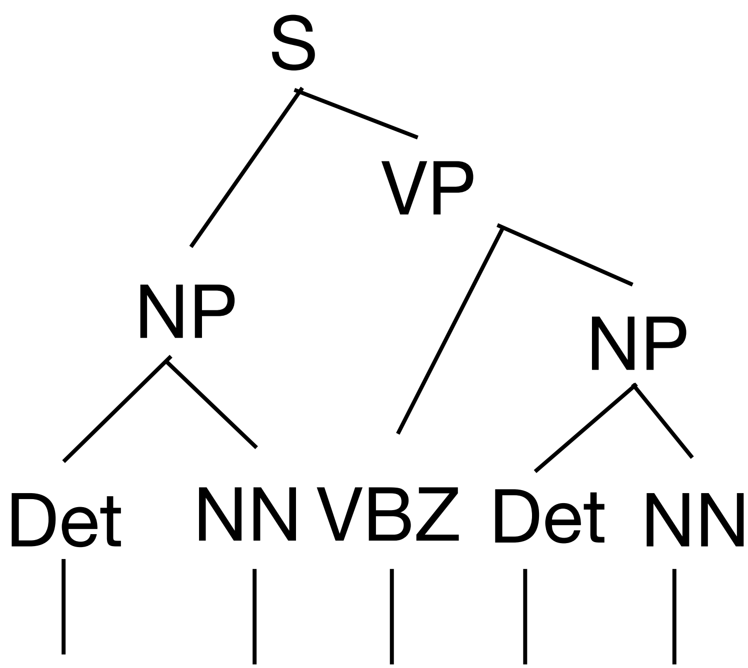
Quantifier Scope Ambiguity



S → NP VP { NP.sem(VP.sem) }

NP → Det NN { Det.sem(NN.sem) }

VP → VBZ NP { VBZ.sem(NP.sem) }

Det → every { $\lambda f.\lambda g.\forall u\ f(u) \Rightarrow g(u)$ }

Det → a { $\lambda m.\lambda n.\exists x\ m(x) \land n(x)$ }

NN → man { $\lambda v.Man(v)$ }

NN → woman { $\lambda y.Woman(y)$ }

VBZ → loves { $\lambda h.\lambda k.h(\lambda w.\ Loves(k, w))$ }

- *Every man loves a woman*.

- $\forall u\ Man(u) \Rightarrow \exists x\ Woman(x) \land Loves(u, x)$

This Isn't Quite Right!

- "*Every man loves a woman*" really is ambiguous.
  - $\forall u\ Man(u) \Rightarrow \exists x\ Woman(x) \wedge Loves(u, x)$
  - $\exists x\ Woman(x) \wedge \forall u\ Man(u) \Rightarrow Loves(u, x)$

- This gives only one of the two meanings.
  - Extra ambiguity on top of syntactic ambiguity
- One approach is to delay the quantifier processing until the end, then permit any ordering.

Quantifier Scope

- A seat was available for every customer.
- A toll-free number was available for every customer.

- A secretary called each director.
- A letter was sent to each customer.

- Every man loves a woman who works at the candy store.
- Every 5 minutes a man gets knocked down

  and he’s not too happy about it.

What Else?

- Chapter 18 discusses how you can get this to work for other parts of English (e.g., prepositional phrases).
- Remember attribute-value structures for parsing with more complex terminals than simple symbols?
  - You can extend those with semantics as well.
- No time for ...
  - Statistical models for semantics
  - Parsing algorithms augmented with semantics
  - Handling idioms

Extending FOL

- To handle sentences in non-mathematical texts, you need to cope with additional NL phenomena
- Happily, philosophers/logicians have thought about this too

Generalized Quantifiers

- In FOL, we only have universal and existential quantifiers
- One formal extension is type-restriction of the quantified variable: *Everyone likes Udipi*:

  $\forall x$ Person(x) $\Rightarrow$ Likes(x, Udipi)   becomes

  $\forall x \mid$ Person(x).Likes(x, Udipi)

- English and other languages have a much larger set of quantifiers: *all, some, most, many, a few, the, …*
- These have the same *form* as the original FOL quantifiers with type restrictions:

  <quant><var>|<restriction>.<body>

Generalized Quantifier examples

- *Most dogs bark*

  Most x | Dog(x) . Barks(x)

- *Most barking things are dogs*

  Most x | Barks(x) . Dog(x)

- *The dog barks*

  The x | Dog(x) . Barks(x)

- *The happy dog barks*

  The x | (Happy(x) ∧ Dog(x)) . Barks(x)

- ***Interpretation*** and ***inference*** using these are harder…

Speech Acts

- ***Mood*** of a sentence indicates relation between speaker and the concept (proposition) defined by the LF
- There can be operators that represent these relations:
  - ASSERT: the proposition is proposed as a fact
  - YN-QUERY: the truth of the proposition is queried
  - COMMAND: the proposition describes a requested action
  - WH-QUERY: the proposition describes an object to be identified

ASSERT (Declarative mood)

- *The man eats a peach*

  ASSERT(The x | Man(x) . (A y | Peach(y) . Eat(x,y)))

YN-QUERY (Interrogative mood)

- *Does the man eat a peach?*

    YN-QUERY(The x | Man(x) . (A y | Peach(y) . Eat(x,y)))

COMMAND (Imperative mood)

- *Eat a peach, (man).*

  COMMAND(A y | Peach(y) . Eat(*HEARER*,y))

WH-QUERY

- *What did the man eat?*

  WH-QUERY(The x | Man(x) . (WH y | Thing(y) . Eat(x,y)))

- One of a whole set of new quantifiers for wh-questions:
  - *What*: WH x | Thing(x)
  - *Which dog*: WH x | Dog(x)
  - *Who*: WH x | Person(x)
  - *How many men*: HOW-MANY x | Man(x)

Other complications

- Relative clauses are propositions embedded in an NP
  - Restrictive versus non-restrictive: *the dog that barked all night* vs. *the dog, which barked all night*
- Modal verbs: non-transparency for truth of subordinate clause: *Sue thinks that John loves Sandy*
- Tense/Aspect
- Plurality
- Etc.

One of the most successful of these institutions is BancoSol in Bolivia.

```
(*A-BE
   (FORM FINITE)
   (TENSE PRESENT)
   (MOOD DECLARATIVE)
   (PUNCTUATION PERIOD)
   (IMPERSONAL -)
   (THEME
      (*G-PARTITIVE
         (SUBSTANCE
            (*G-PARTITIVE
                (SUBSTANCE
                   (*O-INSTITUTION
                       (UNIT -)
                       (NUMBER PLURAL)
                       (REFERENCE DEFINITE)
                       (DISTANCE NEAR)
                       (PERSON THIRD)))
                (ADJECTIVE
                   (*P-SUCCESSFUL
                       (DEGREE SUPERLATIVE)))))
         (QUANTIFIER (*QUANT-ONE))))
   (PREDICATE
      (*PROP-BANCOSOL
         (NUMBER SINGULAR)
         (IMPLIED-REFERENCE +)
         (PERSON THIRD)
         (UNIT -)
         (Q-MODIFIER
            (*K-IN
               (OBJECT
                  (*PROP-BOLIVIA
                     (UNIT -)
                     (NUMBER SINGULAR)
                     (IMPLIED-REFERENCE +)
                     (PERSON THIRD))))))))
```

Computational Discourse

What Is Discourse?

Discourse is the coherent structure of language above the level of sentences or clauses. A **discourse** is a coherent structured group of sentences.

What makes a passage coherent?

A practical answer: It has meaningful connections between its utterances.

Cover of Shel Silverstein's *Where the Sidewalk Ends* (1974)

Applications of Computational Discourse

- Automatic essay grading
- Automatic summarization
- Meeting understanding
- Dialogue systems

Kinds of discourse analysis

- Discourse: monologue, dialogue, (conversation)

- Discourse (*SLP* Ch. 21) vs. (Spoken) Dialogue Systems (*SLP* Ch. 24)

Discourse mechanisms vs. Coherence of thought

- “Longer-range” analysis (discourse) vs. “deeper” analysis (real semantics):
  - *John bought a car from Bill*
  - *Bill sold a car to John*
  - *They were both happy with the transaction*

Coherence, Cohesion

- Coherence relations:
  - *John hid Bill's car keys. He was drunk.*
  - *John hid Bill's car keys. He likes spinach.*

- Entity-based coherence (Centering) and lexical cohesion:
  - *John went to the store to buy a piano*
  - *He had gone to the store for many years*
  - *He was excited that he could finally afford a piano*
  - *He arrived just as the store was closing for the day*

  versus
  - *John went to the store to buy a piano*
  - *It was a store he had gone to for many years*
  - *He was excited that he could finally afford a piano*
  - *It was closing for the day just as John arrived*

Cohesion in NLP

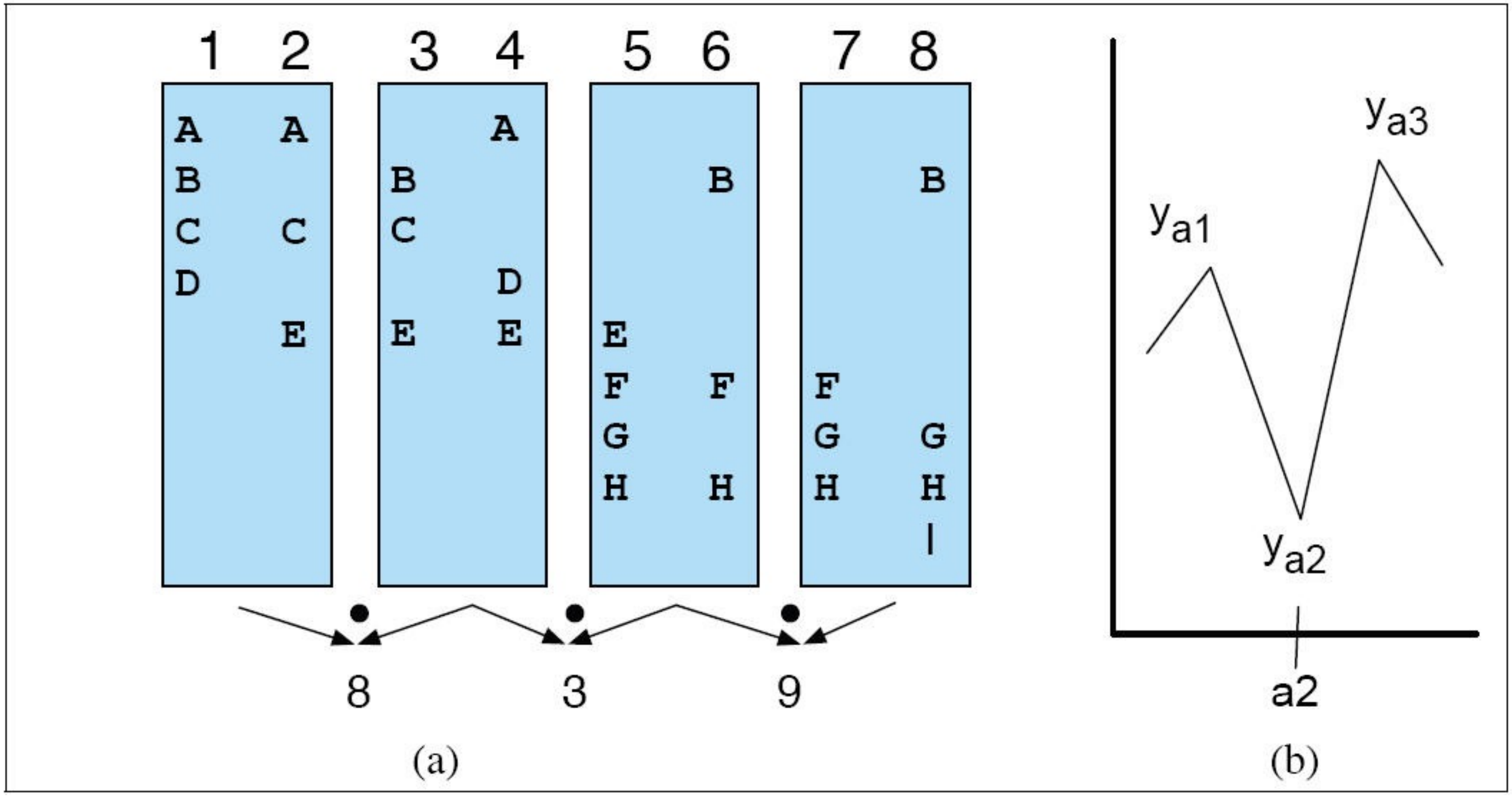
Discourse Segmentation

Goal: Given raw text, separate a document into a linear sequence of subtopics.

1-3	Intro - the search for life in space
4–5	The moon's chemical composition
6-8	How early earth-moon proximity shaped the moon
9–12	How the moon helped life evolve on earth
13	Improbability of the earth-moon system
14–16	Binary/trinary star systems make life unlikely
17–18	The low probability of nonbinary/trinary systems
19–20	Properties of earth's sun that facilitate life
21	Summary

Pyramid from commons.wikimedia.org

Discourse segmentation: TextTiling



- Using dips in **cohesion** to segment text.

Coherence in NLP

Coherence Relations

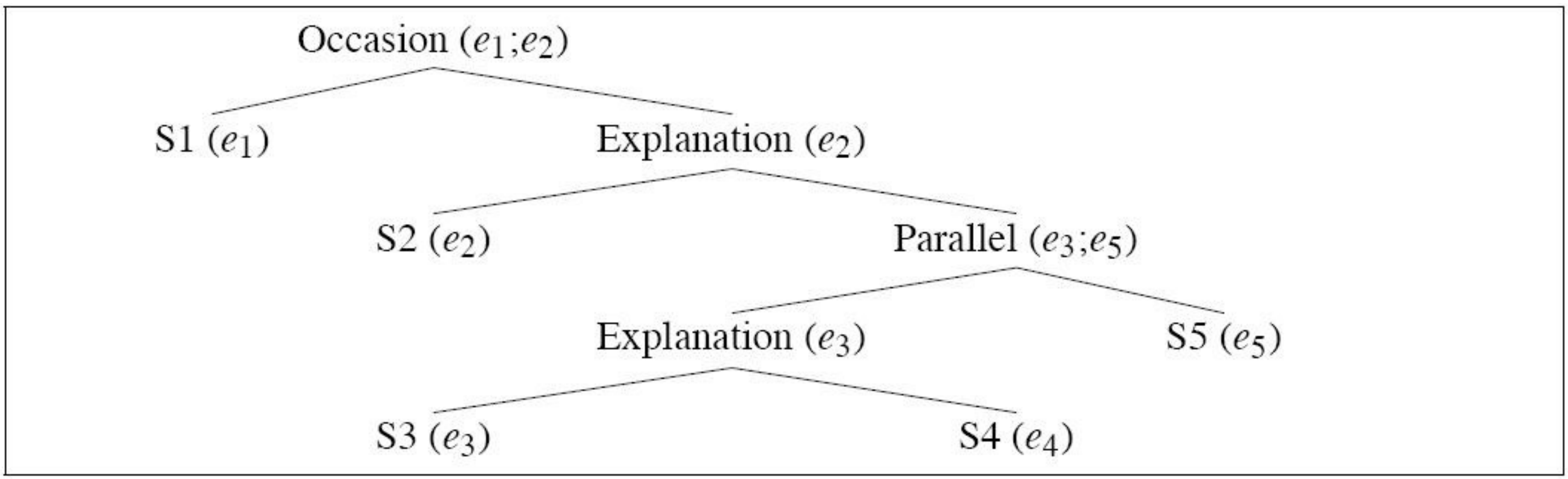
S1: *John went to the bank to deposit his paycheck*

S2: *He then took a bus to Bill's car dealership*

S3: *He needed to buy a car*

S4: *The company he works for now isn't near a bus line*

S5: *He also wanted to talk with Bill about their soccer league*

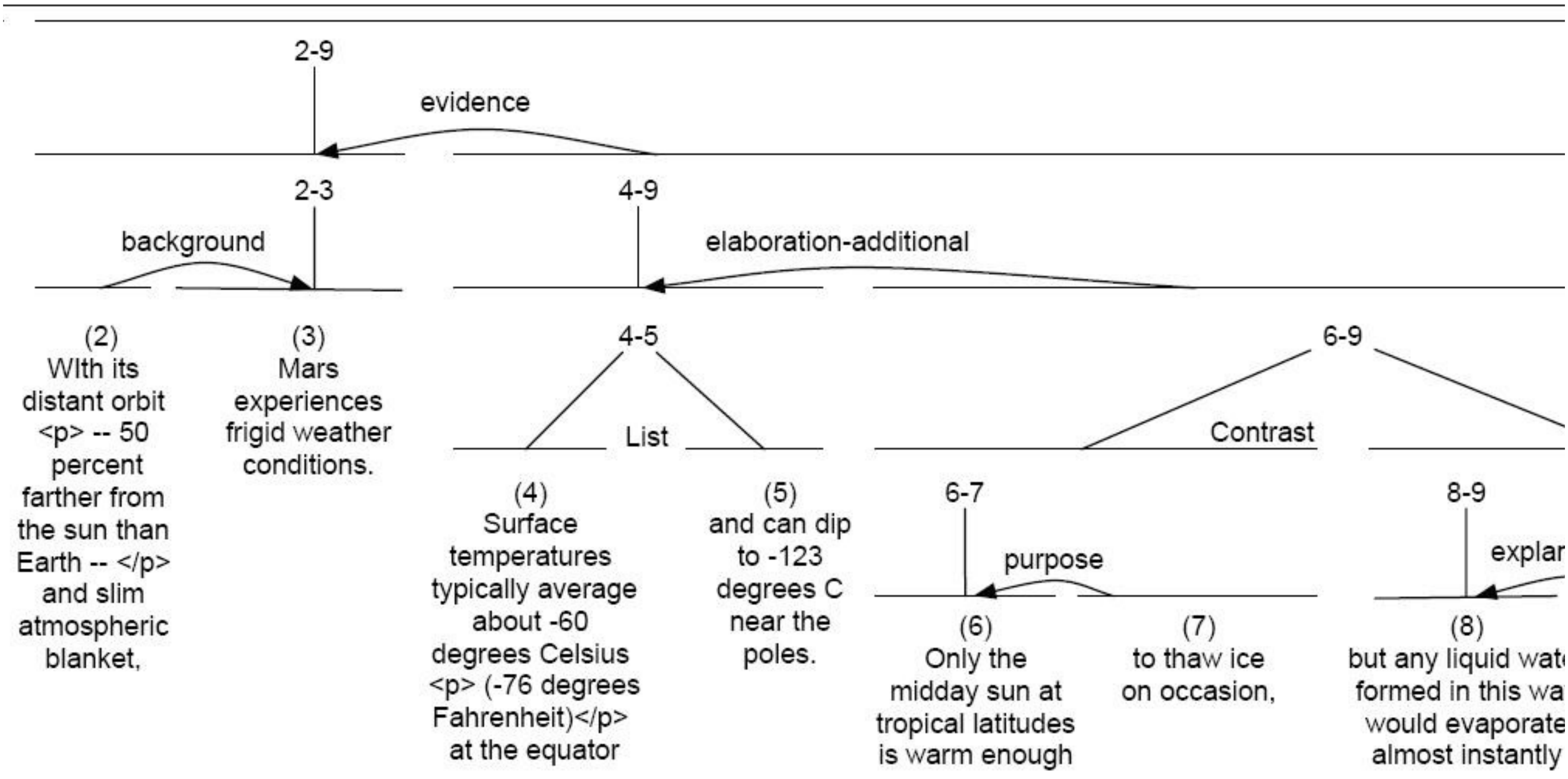


Some Coherence Relations

How can we label the relationships between utterances in a discourse? A few examples:

- **Explanation**: Infer that the state or event asserted by S_1 causes or could cause the state or event asserted by S_0.
- **Occasion**: A change of state can be inferred from the assertion of S_0, whose final state can be inferred from S_1, or vice versa.
- **Parallel**: Infer $p(a_1, a_2,\ldots)$ from the assertion of S_0 and $p(b_1, b_2,\ldots)$ from the assertion of S_1, where a_i and b_i are similar for all i.

RST Coherence Relations



RST formal relation definition

- Relation name: **Evidence**
- Constr on N: R not believing N enough for W
- Constr on S: R believes S, or would
- Constr on N+S: R’s believing S would increase R’s believing N
- Effects: R’s belief of N is increased

Automatic Coherence Assignment

Given a sequence of sentences or clauses , we want to automatically:

- determine coherence relations between them (coherence relation assignment)
- extract a tree or graph representing an entire discourse (discourse parsing)

Automatic Coherence Assignment

Very difficult. One existing approach is to use cue phrases.

John hid Bill's car keys because he was drunk.
The scarecrow came to ask for a brain. Similarly, the tin man wants a heart.

1) Identify cue phrases in the text.
2) Segment the text into discourse segments.
3) Classify the relationship between each consecutive discourse segment.

Automatic Coherence Assignment

- "Discourse parsing"?
- Use **cue phrases**/discourse markers
  - *although, but, because, yet, with, …*
  - but often implicit, as in car key example
- Use **abduction**, defeasible inference
  - All men are mortal
  - Max was mortal
  - **Maybe** Max was a man
- *The **city** denied the **demonstrators** a permit because **they** (**feared**/**advocated**) violence*

Pragmatics

Pragmatics

Pragmatics is a branch of linguistics dealing with language use in context.

When a diplomat says yes, he means ‘perhaps’;

When he says perhaps, he means ‘no’;

When he says no, he is not a diplomat.

(Variously attributed to Voltaire, H. L. Mencken, and Carl Jung)

Quote from http://plato.stanford.edu/entries/pragmatics/

In Context?

- Social context
  - Social identities, relationships, and setting
- Physical context
  - Where? What objects are present? What actions?
- Linguistic context
  - Conversation history
- Other forms of context
  - Shared knowledge, etc.

Speech Acts

(Direct) Speech Acts

- ***Mood*** of a sentence indicates relation between speaker and the concept (proposition) defined by the LF
- There can be operators that represent these relations:
  - ASSERT: the proposition is proposed as a fact
  - YN-QUERY: the truth of the proposition is queried
  - COMMAND: the proposition describes a requested action
  - WH-QUERY: the proposition describes an object to be identified

Indirect Speech Acts

- Can you pass the salt?

- It’s warm in here.

Austin: How to do things with words

- In addition to just saying things, sentences perform actions.
- When these sentences are uttered, the important thing is not their truth value, but the ***felicitousness*** of the action (e.g., do you have the ***authority*** to do it):
  - I name this ship the Queen Elizabeth.
  - I take this man to be my husband.
  - I bequeath this watch to my brother.
  - I declare war.
    - http://en.wikipedia.org/wiki/J._L._Austin

Performative sentences

- You can tell whether sentences are performative by adding “**hereby**”:
  - I hereby name this ship the Queen Elizabeth.
  - I hereby take this man to be my husband.
  - I hereby bequeath this watch to my brother.
  - I hereby declare war.
- Non-performative sentences do not sound good with hereby:
  - Birds hereby sing.
  - There is hereby fighting in Syria.

Austin continued

- *Locution*: say some words
- *Illocution*: an action performed *in* saying words
  - Ask, promise, command
- *Perlocution*: an action performed *by* saying words, probably the effect that an illocution has on the listener.
  - Persuade, convince, scare, elicit an answer, etc.

Searle’s speech acts

Searle (1975) has set up the following classification of illocutionary speech acts:

- **assertives** = speech acts that commit a speaker to the truth of the expressed proposition, e.g. reciting a creed
- **directives** = speech acts that are to cause the hearer to take a particular action, e.g. requests, commands and advice
- **commissives** = speech acts that commit a speaker to some future action, e.g. promises and oaths
- **expressives** = speech acts that express the speaker's attitudes and emotions towards the proposition, e.g. congratulations, excuses and thanks
- **declarations** = speech acts that change the reality in accord with the proposition of the declaration, e.g. baptisms, pronouncing someone guilty or pronouncing someone husband and wife

  - http://en.wikipedia.org/wiki/Speech_act

Searle example

- Indirect speech acts:
  - Can you pass the salt?
    - Has the form of a *question*, but the effect of a *directive*.

Speech Acts in NLP

Task-Oriented Dialogue

- Making travel reservations (flight, hotel room, etc.)
- Scheduling a meeting.
- Task oriented dialogues that are frequently done with computers:
  - Finding out when the next bus is.
  - Making a payment over the phone.

Ways to ask for a room

- I’d like to make a reservation
- I’m calling to make a reservation
- Do you have a vacancy on ...
- Can I reserve a room
- Is it possible to reserve a room

Task-oriented dialogue acts related to negotiation

- Suggest
  - I recommend this hotel.
- Offer
  - I can send some brochures.
  - How about if I send some brochures.
- Accept
  - Sure. That sounds fine.
- Reject
  - No. I don’t like that one.

Domain-specific speech acts:
travel scheduling (NESPOLE! Project)
(a primitive version of the speech translation)

- 61.2.3 olang ITA lang ITA Prv IRST "Telefono per prenotare delle stanze per quattro colleghi"
- 61.2.3 olang ITA lang ENG Prv IRST "I am calling to book some rooms for four colleagues"
- 61.2.3 IF Prv IRST c:request-action+reservation+room (room-spec=(room, quantity=some), for-whom=(colleague, quantity=4))
- comments: dial-oo5-spkB-roca0-02-3

"No, Thursday's out. How about never—is never good for you?"

Now, a famous bad idea

(linked to a good idea)

Grice’s Maxims

- Why do these make sense?
  - *Are you 21?*
  - *Yes. I’m 25.*

  - *I’m hungry.*
  - *I’ll get my keys.*

  - *Where can I get cigarettes?*
  - *There is a gas station across the street.*

Grice’s Maxims

- Why are these strange?

  - (The students are all girls.)
  - *Some students are girls.*

  - (There are seven non-stop flights.)
  - *There are three non-stop flights.*
    - Jurafsky and Martin, page 820

  - (In a letter of recommendation for a job)
  - *I strongly praise the applicant’s impeccable handwriting.*

Grice's *Cooperative Principle*

- "Make your contribution such as it is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which you are engaged."
- The Cooperative Principle is good and right.
- On the other hand, we have the Maxims:

Grice’s actual Maxims

- Maxim of Quality
  - Try to say something true; do not say something false or for which you lack evidence.
- Maxim of Quantity
  - Say as much as is required to be informative
  - Do not make your contribution more informative than required
- Maxim of Relevance
  - Be Relevant
- Maxim of Manner
  - Be perspicuous
  - Avoid ambigtuity
  - Be brief
  - Be orderly

Flouting the Cooperative Principle

- "Nice throw." *(said after terrible throw)*

- "If you run a little slower, you'll never catch up to the ball." *(during mediocre pursuit of ball)*

- You *can* indeed imply something by clearly violating the principle.
  - The Maxims *still* suck.

Flout ≠ *Flaunt*

- *Flout*: openly disregard (a rule, law or convention).

- *Flaunt*: display (something) ostentatiously, especially in order to provoke envy or admiration or to show defiance.
  - Source: Google

My paper on the Maxims

- Grice's Maxims: "Do the Right Thing" by Robert E. Frederking. Argues that the Gricean maxims are too vague to be useful for natural language processing. [from Wikipedia article]

- "I used to think you were a nice guy."
  - Actual quote from a grad student, after reading the paper

Reference resolution

Reference Resolution: example

- Victoria Chen, CFO of Megabucks Banking Corp since 2004, saw her pay jump 20%, to $1.3 million, as the 37-year-old also became the Denver-based company's president. It has been ten years since she came to Megabucks from rival Lotsaloot.

- Should give 4 coreference chains:
  - {Victoria Chen, CFO of Megabucks Banking Corp since 2004, her, the 37-year-old, the Denver-based company's president, she}
  - {Megabucks Banking Corp, the Denver-based company, Megabucks}
  - {her pay}
  - {Lotsaloot}

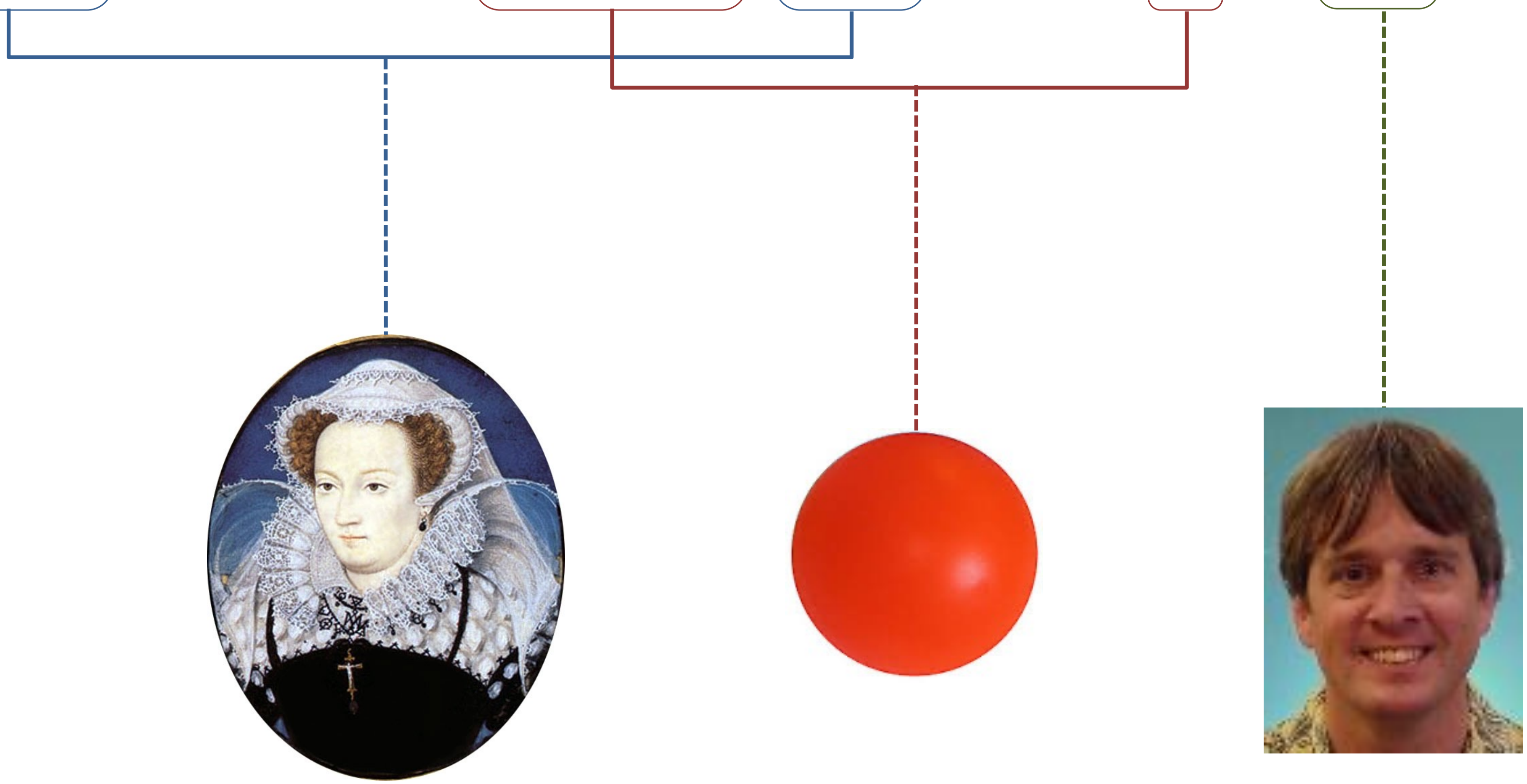
  .

Coreference Resolution

Mary picked up the ball. She threw it to me.

Reference resolution

Mary picked up the ball. She threw it to me.



(Co)Reference Resolution

- Determining the referent of a referring expression. Anaphora, antecedents corefer.
- 1961 Ford Falcon: *it, this, that, this car, the car, the Ford, the Falcon, my friend's car, …*
- Coreference chains are part of cohesion
- Note: other kinds of referents:
  - *According to Doug, Sue just bought the Ford Falcon*
    - *But **that** turned out to be a lie*
    - *But **that** was false*
    - ***That** struck me as a funny way to describe the situation*
    - ***That** caused a financial problem for Sue*

Types of Referring Expressions

- Indefinite NPs: *a/an, some, this*, or nothing
  - new entities; specific/non-specific ambiguity
- Definite NPs: usually *the*
  - an entity identifiable by the hearer
- Pronouns: *he, them, it*, etc. Also **cataphora**.
  - strong constraints on their use
  - can be bound: *Every student improved his grades*
- Demonstratives: *this, that*
- Names: construed to be unique, but they aren't
  - *Is that the Bob in LTI or the Bob in the Lane Center?*

Information structure: given/new

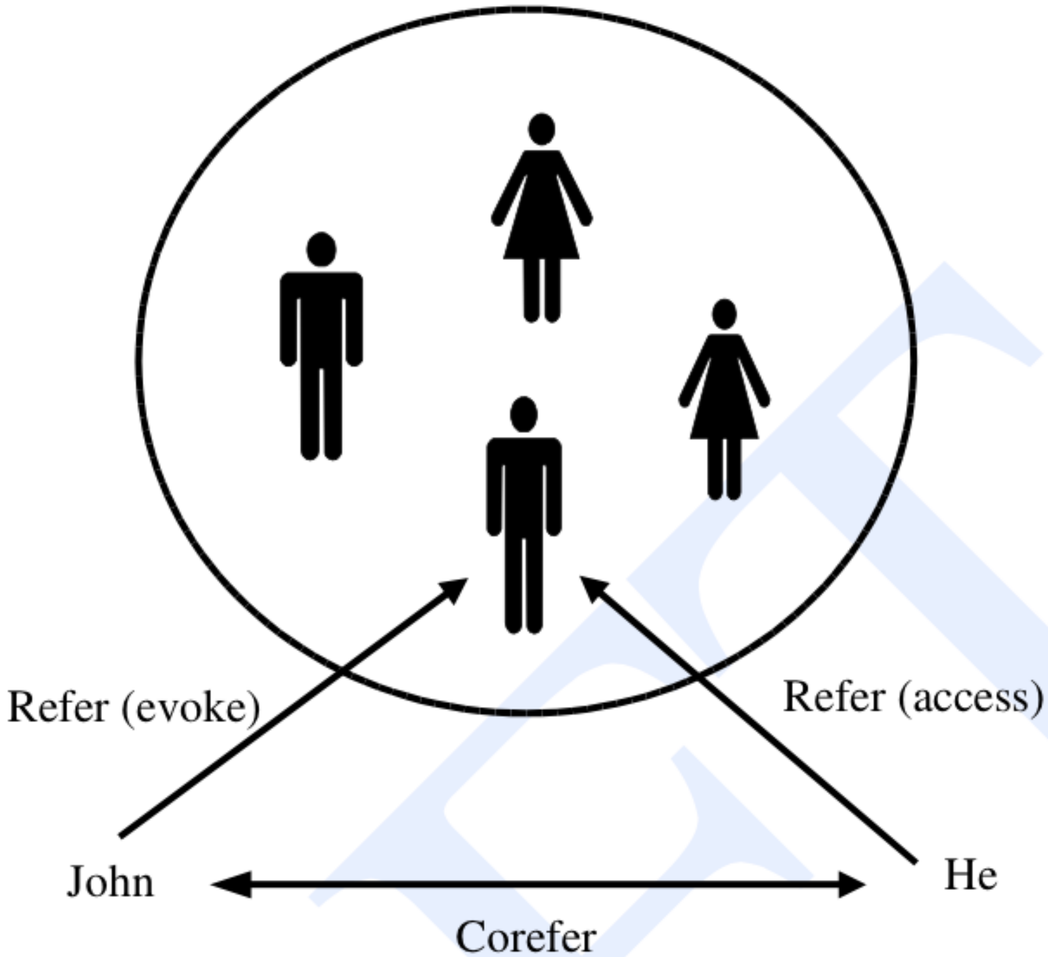
- *Where are my **shoes**? Your shoes are in the **closet***
- *What's in the **closet**?*
  - *??Your shoes are in the **closet**.*
  - *Your **shoes** are in the closet.*

- Definiteness/pronoun, length, position in S

Complications

- Inferrables: *Some car. … a door … the engine …*
- Generics: *At CMU you have to work hard.*
- Pleonastic/clefts/extraposition:
  - *It is raining. It was me who called. It was good that …*

Discourse models



Reference Resolution:

Goal: determine what entities are referred to by which linguistic expressions.

The **discourse model** contains our eligible set of referents.

Simple DRS example (DRT by Kamp)

6.12. Example (Preceded by "A woman snorts".)

1. A woman walks. She collapses.

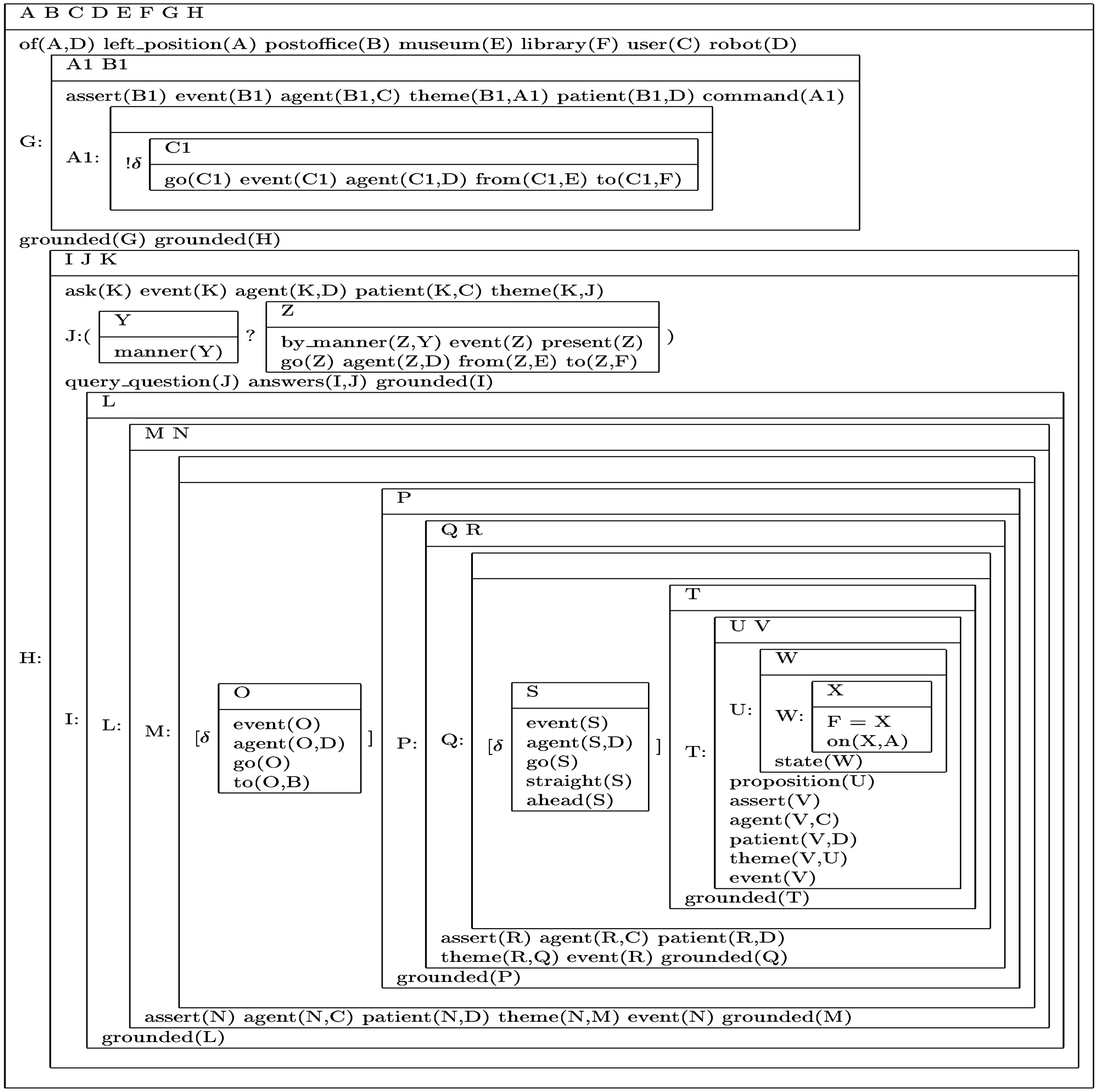
x, y
$woman(x)$
$snort(x)$
$collapse(y)$
$y = x$

2. Every woman walks. *She collapses.

y
$\boxed{\begin{array}{c} x \\ \hline woman(x) \end{array}} \Rightarrow \boxed{\begin{array}{c} \\ \hline walk(x) \end{array}}$ $collapses(y)$
$^{*}y = x$

from Raffaella Bernardi, Trento

Complex DRS example



from Stanislao et al 2001

Pronouns:
Filters and Preferences

Pronoun reference resolution: filters

- Agreement in number, person, gender
    - Pittsburgh dialect: *yinz=youse=y'all*
    - UK dialect: *Newcastle are a physical team*.
  - L can have >2 numbers, >3 persons, or >3 genders
- Binding theory: **reflexive** required/prohibited:
  - *John bought himself a new Ford.* [himself=John]
  - *John bought him a new Ford*. [him!=John]
  - *John said that Bill bought him a new Ford*. [him!=Bill]
  - *J said that B bought himself a new F*. [himself=Bill]
  - *He said that he bought J a new Ford*. [*both* he!=J]

Pronoun reference resolution: preferences

- Recency: preference for most recent referent
- Grammatical Role: subj>obj>others
  - *Billy went to the bar with Jim. He ordered rum*.
- Repeated mention: *Billy had been drinking for days. He went to the bar again today. Jim went with him. He ordered rum.*
- Parallelism: *John went with Jim to one bar. Bill went with him to another.*
- Verb semantics: *John phoned/criticized Bill. He lost the laptop.*
- Selectional restrictions: *John parked his car in the garage after driving it around for hours.*

Baseline: Hobbs Algorithm

- Algorithm for walking through parses of current and preceding sentences
- Simple, often used as baseline

- Requires parser, morph gender and number
  – plus head rules and WordNet for NP gender
- Implements binding theory, recency, and grammatical role preferences

Another approach: Centering theory

- Claim: a single entity is “centered” in each S
- Backward-looking center, Forward-looking centers
- C_b = most highly ranked C_f used from prev. S
- Rank: Subj>ExistPredNom>Obj>IndObj-Obl>DemAdvPP
- Defined transitions: (Cp is front of Cf list)

	$C_b(U_{n+1}) = C_b(U_n)$ or undefined $C_b(U_n)$	$C_b(U_{n+1}) \neq C_b(U_n)$
$C_b(U_{n+1}) = C_p(U_{n+1})$	Continue	Smooth-Shift
$C_b(U_{n+1}) \neq C_p(U_{n+1})$	Retain	Rough-Shift

Rule 1: If any C_f used as Pro_{n+1}, then $C_{b(n+1)}$ must be Pro too

Rule 2: Rank: Continue>Retain>Smooth>Rough

General Reference Resolution

General Coreference Resolution

- Victoria Chen, CFO of Megabucks Banking Corp since 2004, saw her pay jump 20%, to $1.3 million, as the 37-year-old also became the Denver-based company's president. It has been ten years since she came to Megabucks from rival Lotsaloot.

- Should give 4 coreference chains:
  - {Victoria Chen, CFO of Megabucks Banking Corp since 2004, her, the 37-year-old, the Denver-based company's president, she}
  - {Megabucks Banking Corp, the Denver-based company, Megabucks}
  - {her pay}
  - {Lotsaloot}

.

President Park Geun-hye of South Korea ordered the country's military on Monday to deliver a strong and immediate response to any North Korean provocation, the latest turn in a war of words that has become a test of resolve for the relatively unproven leaders in both the North and South.

"I consider the current North Korean threats very serious," Ms. Park told the South's generals. "If the North attempts any provocation against our people and country, you must respond strongly at the first contact with them without any political consideration.

"As top commander of the military, I trust your judgment in the face of North Korea's unexpected surprise provocation," she added.

Since Kim Jong-un took power after the death of his father, Kim Jong-il, in late 2011, the North has taken a series of provocative steps and amplified threats against Washington and Seoul to much louder and more menacing levels. The North has launched a three-stage rocket, tested a nuclear device and threatened to hit major American cities with nuclear-armed ballistic missiles. And Mr. Kim has declared that the Korean Peninsula has reverted to a "state of war."

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High-Level Recipe for Coreference Resolution

1. Parse the text and identify NPs; then
2. For every pair of NPs, carry out binary classification: coreferential or not?
3. Collect the results into coreferential chains

What do we need?

-A choice of classifier

-Lots of labeled data

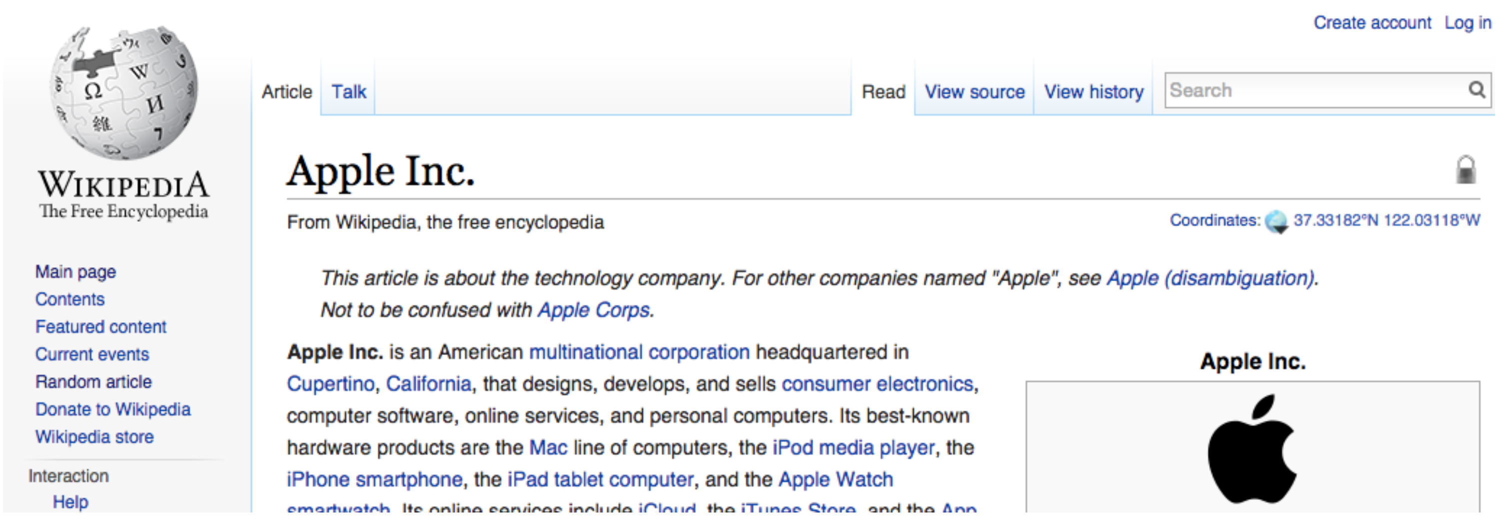
-Features

Features?

- Edit distance between the two NPs
- Are the two NPs the same NER type?
- Appositive syntax
  - "Alan Shepherd, the first American astronaut…"
- Proper/definite/indefinite/pronoun
- Gender
- Number
- Distance in sentences
- Number of NPs between
- Grammatical role
- etc.

Entity Linking

Apple updated its investor relations page today to note that it will announce its earnings for the second fiscal quarter (first calendar quarter) of 2015 on Monday, April 27.



News text from http://www.macrumors.com/2015/03/30/apple-to-announce-q2-2015-earnings-on-april-27/

One Approach to Entity Linking

Use supervised learning: Train on known references to each entity. Use features from context (bag of words, syntax, etc.).


iPhone

From Wikipedia, the free encyclopedia

This article is about the line of smartphones by Apple. For other uses, see iPh disambiguation).

iPhone (/ˈaɪfoʊn/ *EYE-fohn*) is a line of smartphones designed and marketed by Apple Inc. It runs Apple's iOS mobile operating system.[13] The first generation iPhone was released on June 29, 2007; the most recent iPhone models are the iPhone 6 and iPhone 6 Plus, which were unveiled at a special event on September 9, 2014.[14]

Questions?